Safety and Cryo-design

The design of the LH2 absorber cryo system must meet the requirements of the report "Guidelines for the Design, Fabrication, Testing, Installation and Operation of LH2 Targets – 20 May 1997" by Del Allspach

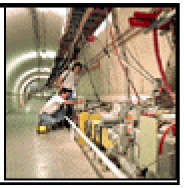
Test facility

LH2 Absorber

- Aluminum 6061 T6 and series 300 Stainless-steel
- Design for a MAWP of 25 psid..
- PSRV sized to relieve at 10 psig (25 psid)

Vacuum vessel

- Aluminum 6061 T6 and series 300 Stainless-steel
- Stress analysis for mechanical and thermal loads
- Design for a MAWP of at least 15 psig internal
- PSRV sized to relieve less than 15 psig (30 psia)



Safety and Cryo-design

The Pressure safety valves

Sized for the cases of Hydrogen boil-off in vacuum failure (no fire consideration)

- LH2 loop => Two pressure relieve valves (Anderson Greenwood type) located before and after the LH2 pump

- Vacuum vessel => two parallel plates and a check valve in series with a safety controlled valve

Comments

- Electrical risk– Follow guidelines – NEC Requirements for H2
- Second containment vessel avoided if possible.
- Hydrogen vent

Vacuum vessel - Cryostat window thickness

- Parameters that influence the mechanical choice of the window:
  - Pressure (value, direction) => 2 Configurations
  - Shape
  - Material
  - Diameter

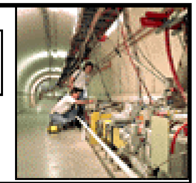
- Pressure configurations

Case A) two windows to be separated by the atmosphere

Beam pipe vacuum----wind#1----atm----wind#2----Cryostat vacuum => P=15 psid
twice the thickness

Case B) one window in between both vacuums

Beam pipe vacuum----wind#1----Cryostat vacuum => P=30 psid



Vacuum vessel - Cryostat window thickness

⌘ Shape

The maximum allowable stress in the window should be the smaller of:

Su x 0.4 or Sy x 2/3

<u>Flat plate</u>

$$\mathrm{Sigma} = E\cdot\frac{tk^2}{a^2}\cdot\left[K3\cdot\frac{y}{tk} + K4\cdot\left(\frac{y}{tk}\right)^2\right]$$

$$K3 = 4.286$$

$$K4 := 0.976$$

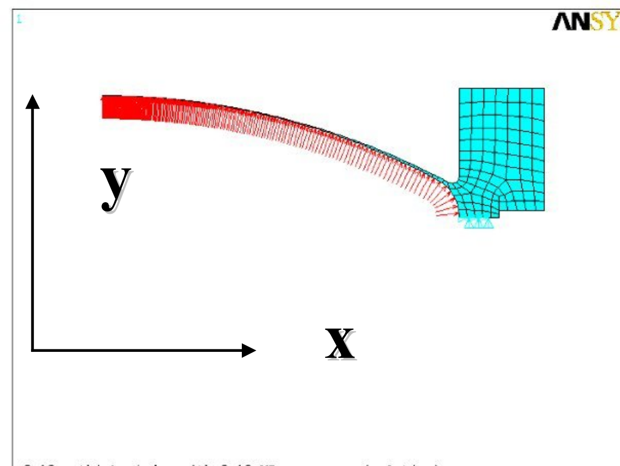
$$f(y) := K1\cdot\frac{y}{tk} + K2\cdot\left(\frac{y}{tk}\right)^3 - q\cdot\frac{a^4}{E\cdot tk^4}$$

$$K1 := \frac{5.33}{\left(1 - v^2\right)}$$

$$K2 := \frac{2.6}{\left(1 - v^2\right)}$$

<u>Torispherical</u>

Finite element analysis =>



Vacuum vessel - Cryostat window thickness

- Materials (need exact material physical properties)

Materials	E (GPa/10^6 psi)	Ultimate stress (MPa/ksi)	Yield stress (MPa/ksi)
Titanium – Ti 15-3-3	92.4/13.40	835.0/121.10	737.7/107.0
Aluminum – 6061 T6	68.0/9.86	312.0/45.25	282.0/40.9
Beryllium – S-200E	251.0/36.41	485.4/70.40	297.9/43.2

- Diameter

Even if the muon beam diameter can vary along the cooling channel, the first containment window should keep the same diameter

➔ D= 22 cm (8.66”)

Cryostat window thickness – Potential solutions 22-cm window

Flat plate thickness (mm)

Materials	W/ Atmosphere interface 2 windows, 15 psid	W/o Atmosphere interface 1 window, 30 psid
Titanium – Ti 15-3-3	0.489	0.775
Aluminum – 6061 T6	5.280	3.887
Beryllium – S-200E	4.360	3.080

Torispherical thickness (mm)

Materials	W/ Atmosphere interface 2 windows, 15 psid	W/o Atmosphere interface 1 window, 30 psid
Aluminum – 6061 T6	0.304	0.260